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ABSTRACT

This paper attempts to generate a comprehensive description of the nature of mathematics anxiety through a synthesis of: (1) the general and test anxiety literatures applied to mathematics anxiety; (2) the mathematics anxiety literature, and (3) case studies developed through in-depth interviews. The indepth interviews were conducted with seven university students, five of whom were high mathematics anxious and two of whom were low. Mathematics anxiety is defined as a state of anxiety in response to situations involving mathematics which are perceived as threatening to self-esteem. A model of anxiety as a process is developed and presented in the paper. The model includes environmental antecedents, dispositional antecedents, and situational antecedents. It is an interaction of these antecedents which produces an anxiety reaction, with its physiological manifestations. During cognitive reappraisal, decisions are made about dealing with the anxiety. If self-esteem is basically strong and there is a certain level of task-related confidence, the individual may be able to control the anxiety and channel it into the task. When this occurs the anxiety might facilitate performance. However, if the individual is unable to control the anxiety, it can debilitate the performance. There also are ways the individual copes or does not cope with the immediate anxiety situation. Coping for long-term might involve avoidance of mathematics and convincing oneself mathematics is not useful. Forty-one references are appended. (RH)

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The Nature of Mathematics Anxiety

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THE NATURE OF MATHEMATICS ANXIETY

Mathematics anxiety is a presistent learning problem which has received considerable attention in the last ten years. In a unique approach, this paper attempts to generate a comprehensive description of the nature of mathematics anxiety through a synthesis of (a) the general and test anxiety literatures applied to mathematics anxiety, (b) the mathematics anxiety literature, and (c) case studies developed through in-depth interviews.

The in-depth interviews were conducted with seven university students, five who were high mathematics anxious and two who were low. To determine anxiety level, I used my own perceptions, the self-report of the interviewee, and the report of the person who referred the interviewee to the study. The subjective ratings were later corroborated by scores on the Mathematics Anxiety Rating Scale (MARS) (see table 1).

Insert Table 1 about here

Table 1 summarizes basic information about the seven interviewees. Quotations from the interviews were sorted into categories. These categories are combined with the literature reviews to provide a thorough description of just what mathematics anxiety is and a model for future research on this complex phenomenon.

General Anxiety

Charles Spielberger's conceptualization of anxiety as state, trait, and process can provide structure for the study of mathematics anxiety and an operational definition of the construct. He has defined state anxiety as the "unpleasant state or condition which is characterized by activation or arousal of the autonomic nervous system" (Spielberger, 1972, p. 482). State anxiety involves temporally and situationally specific experiences of anxiety, called A-state reactions.

Trait anxiety, on the other hand, is more pervasive. It constitutes "relatively stable individual differences in anxiety proneness as a personality trait" (Spielberger, 1972, p. 482) and implies a tendency to be anxious rather than an actual experience of anxiety.

The distinction between the two can be clarified with the following statements. "Pat is an anxious person" implies trait anxiety since it is a comment about Pat's personality, whereas "Pat is anxious" conveys state anxiety since it implies Pat is anxious right now.

The third definition of anxiety provided by Spielberger is anxiety-as-process, which he has defined as "The sequence of cognitive, affective, and behavioral responses that occur as a a reaction to some form of stress" (Spielberger, 1972, p. 484).

Spielberger's model of anxiety-as-process can be modified as follows:

STRESSOR → PERCEPTION OF THREAT → A-STATE REACTION → COGNITIVE REAPPRAISAL → COPING

According to the model, when an individual experiences anxiety, first there is the presence of something in the environment which has the potential for producing anxiety, a stressor. However, the stressor does not produce anxiety unless it is perceived by the individual as a psychological threat. The A-state reaction has concommitant physiological reactions. Then, during cognitive reappraisal, the individual decides how to deal with the anxiety and the original stressor, which is carried out in the final step, coping. One possible form of coping with mathematics anxiety is avoidance of mathematics.

Threat to Self Esteem

To understand how anxiety is precipitated on a basic level, it is useful to compare anxiety to fear. When people are threatened physically, they may react with fear. Concommitant with the fear are reactions such as an increase in heart rate, respiration rate, and blood pressure; muscle tension; and relief of kidney and bowels. These physiological reactions are useful for flight or fight, the possible forms of defense against physical threat. Analogously, when people are threatened psychologically, they react with anxiety. The physical reactions are practically the same as with fear. Although the increase in metabolism helps the individual either avoid the physical danger by running, or combat it by fighting, it is not useful in combatting psychological danger where physical fight or flight are not appropriate. Thus, the individual experiences anxiety, with its related manifestations.

On a simplistic level, anxiety is precipitated by a perception of psychological threat,

the most prominent of which is threat to self esteem (Epstein, 1976; May, 1950). Individuals must protect the concept they have of themselves as valuable human beings. When something, such as failure in a mathematics class, challenges this perception of self, the individual may begin to doubt his or her self worth, feel psychologically threatened, and experience anxiety.

Defining Mathematics Anxiety

Based on the previous discussion, mathematics anxiety can be defined as a state anxiety in response to situations involving mathematics which are preceived as threatening to self esteem. Consistent with the classic symptoms found in the literature, the individuals I interviewed said mathematics anxiety involves a nervous stomach (also described as butterflies), sweating and sweaty palms, muscle contractions, a tightness in chest or throat, difficuly breathing, heart palpitations, tension headaches, restlessness or fidgety behavior, feeling upset, and blanking out. For example, Dan described his mathematics anxiety, "When confronted with a mathematical situation or any set of numbers with which I am not extremely familar, a tightness in my chest and throat occurs and there are muscular contractions. Sometimes it means actually sweating." The anecdotes describing panic often reported in the literature (e.g. Buxton, 1982; Kogelman & Warren, 1978; Tobias, 1978) might be part of an extreme anxiety reaction.

In addition to these specific experiences of anxiety, there is a more trait-like anxiety implicit in "a mathematics-anxious person" which involves a tendency to be anxious about mathematics. Finally, each A-state reaction can be considered part of the following process.

STRESSOR (Involving mathematics)	→ PERCEPTION OF THREAT TO SELF ESTEEM	→ MATHEMATICS ANXIETY REACTION	→ COGNITIVE REAPPRAISAL	→ COPING (Including avoidance)

The model of anxiety-as-process is expanded in the remainder of this paper.

Dispostional Antecedents

In anxiety-as-process, prior to the anxiety reaction there are antecedents: factors surrounding the stressor which are situational antecedents and factors contributing to

the perception of threat which are dispositional antecedents (Lazurus & Averill, 1972). Dispositional factors contributing to mathematics anxiety are related to the personality of the individual. They include self doubt, lack of confidence in mathematics ability, attitudes, and sex role.

Self Doubt

Self doubt seems to be one personality factor contributing to mathematics anxiety. One interviewee, Sandy, seemed to doubt herself to a great extent. She said she was sick "a lot" during first grade and therefore got behind in school. Missing out on important topics was particularly detrimental in her case because she had little help with schoolwork in her childhood home, and there were fifty students in her first grade class, so she received virtually no individual attention at school. She said her teachers were strict and aloof and, when she asked for help, they would answer, "What's wrong with you?" Her parents reinforced her growing self doubt by asking "Why can't you get this?" Sandy internalized these questions and began to doubt her self worth; "I started thinking there really must be something wrong (with me)." Others also seemed to doubt their self worth because they were unable to do mathematics. Dan said, "(When I was not perfect in math) I felt real intimidated. I felt like there was this blind spot...I felt like there was something really wrong with me". In a pained voice, Linda said, "I mean if I could do well in every other subject, why wasn't I (in math)? Because I have got the brains to do it, but I don't know what it is that's making me not be able to do it. You know?" These individuals' perceptions of self worth were seriously threatened because they had difficulty with mathematics.

Confidence

Another dispositonal antecedent is lack of confidence in one's ability to do mathematics. Empirical evidence strongly supports a relationship between Fennema and Sherman's Mathematics Anxiety Scale (MAS) and their Confidence in Learning Mathematics Scale (Betz, 1977; Kincaid, 1981; Sherman, 1980). Research also supports a relationship between mathematics anxiety and confidence in ability to perform well on specific mathematics tasks or in specific mathematics-related courses (Hackett, 1985; Lorenz, 1982).

There were several responses in the interviews which indicated a relationship between mathematics anxiety and confidence. Dan said when he doubted his ability to do math-

ematics he would feel "that fog in there, alienation", which he often used to describe his anxiety. Denny said when he does not have confidence, it makes the anxiety stronger "because I don't have the confidence to push it back, to push it down, the anxiety." Finally, Sandy said "Once I know it (mathematics), I won't be anxious about it anymore. As long as there's any doubt that I don't understand, there's still going to be some (anxiety)."

Attitudes

Two attitudes are often associated with mathematics anxiety: perceived usefulness and math as a male domain.

Perceived usefulness. Kincaid (1981) found that low anxious females perceived mathematics as more useful than high anxious females ($p < .001$). The usefulness of mathematics seemed more of an issue with Linda and Denny than with the others, perhaps due to their relative immaturity. Perhaps more interesting than the relationship between the constructs, there was some evidence the question "What do I need this for?" was a psychological defense. Sandy said she knows it is useful, but since she had so much difficulty with it and anxiety over it, she tried to convince herself that she did not need it. When asked if she thought it might be a defense against threat to self esteem, Judy stated:

> Because when you ask a direct question, "Is it useful?", of course
> it is. But, when I'm dealing with it in context and how it was for me,
> Why couldn't they just leave me alone? So it was defense, I think.

Also, Rene said she wondered what she was going to use geometry for when she had difficulty with it and her self esteem was threatened, but usefulness was not an issue for her in algebra since the subject was easy for her.

Mathematics as a male domain. Although there is evidence to support the prevalence of the attitude of mathematics as a male domain (Boswell & Katz, 1980; Burton, 1978), there does not seem to be a clear relationship to mathematics anxiety (Betz, 1977; Kincaid, 1981). The results of my interviews were consistent with these empirical findings. Judy felt she did not receive encouragement in mathematics because she was an artist and a female. She explained:

> And if you don't develop those (math) skills or if it takes extra effort to help
> you develop those skills, it's just your parents, teachers, are not going to

> take the time to do it because you have got a man, you are a woman, you have a man.

Thus, Judy's perception of mathematics as a male domain seemed to affect her learning of mathematics and perhaps her anxiety. However, even though Linda, the other high mathematics-anxious female, also seemed to perceive mathematics as a male domain, she did not think that perception affected her. Concerning the other sex, Dan felt added pressure to do well in mathematics and science partly because he was male. He stated, "I think even more so because I was a male. Remember, I was a Sputnik child...I wanted to do real well. And not only was I not doing well, but I didn't know why." When Denny was asked if he felt this pressure, he said he did not. Thus, it seems that the perception of mathematics as a male domain affected Judy's and Dan's anxiety but not Linda's or Denny's. The pattern indicated by these few individuals supports the findings of quantitative research that there is no clear relationship between these two constructs. Perhaps age is a mediating variable since Judy and Dan were older than Linda and Denny. It is possible that the older interviewees grew up in an age when mathematics was more closely associated with sex role identification and related self esteem than the younger ones or when it was no longer appropriate to admit the association, as suggested by Brush (1985).

Sex Role

The study of mathematics anxiety evolved out of sex differences research. Empirically, females demonstrate higher mathematics anxiety than males (e.g. Bander & Betz, 1981; Betz, 1978; Brush, 1985; Dew, Galassi & Galassi, 1983). These results are often questioned; are females more anxious or just more willing to admit their anxiety? Due to the nature and size of my sample, my research could not address the issue of whether or not mathematics anxiety is more prevalent in females. However, a more basic finding concerning sex roles did evolve. It seems the societal sterotype of mathematics as a male domain contributed to both Judy and Dan's anxiety, but in very different ways because of their different sex roles. The lack of encouragement Judy felt she needed but did not receive because she was female contributed to her anxiety whereas the additional pressure to do well in mathematics Dan felt because he was male contributed to his. Thus, in

both cases, anxiety was generated, in part, because of behavior toward each student which was motivated by sex role stereotyping, but which was inappropriate for that student's needs. Consistent with this finding, Becker (1981) found evidence of differential treatment of males and females in high school geometry.

Situational Antecedents

In anxiety-as-process, situational antecedents include the stressor and contextual factors surrounding it. They only precipitate anxiety if they are preceived by the individual as threatening to self esteem. Situational factors contributing to mathematics anxiety include classroom factors, the way mathematics is taught, the nature of mathematics, and situational antecedents of test anxiety.

Classroom Factors

A dominant factor in most classrooms is the personality of the teacher. My interviewees said teachers who made them comfortable and less anxious in mathematics classes were friendly, open, caring, understanding, relaxed, and approachable. It is easy to see that these personality traits would implicitly convey approval and reduce the chance of threat to self esteem. On the other hand, they said teachers who seemed to contribute to their anxiety were "uptight", critical, aloof, and never asked how the student felt, personality traits which convey disapproval and can threaten self esteem.

Another classroom factor involves aspects of the situation, such as class size, which preclude individual help with mathematics. As discussed above, Sandy felt part of her difficulty in first grade was a lack of individual help catching up after her excessive absenses, due to the size of the class. Similarly, Linda said, "I was in the hospitol a lot as a child...I missed a lot of school, I was out...months at a time." She said that she did not learn very much from the hospital school and when she returned to school, rather than help her, her teachers would often say not to worry about it. She said her parents helped her make up English, but she did not have any help with mathematics. As a result, she did not understand and had difficulty when she had to do the same things in subsequent years, which she perceived as being on a more difficult level. In contrast, even though Rene, who was low in mathematics anxiety, also was sick and missed a lot of school, she said she had a lot of help; "Yeah, my parents would help me, my brother would help me, friends would

help me...when I needed it, I always had help."

The Way Mathematics Is Taught

Another set of situational factors involve the way mathematics is often taught. Sandy said she had difficulty understanding mathematics because of the pace; "It's usually put at ya too fast. And if you don't get it, it just piles up, just throw it in there, don't understand that one. Pretty soon it's cluttered up." It seems the mediating variable between a pace which is perceived as too fast and preceptions of threat to self esteem is the focus of blame for the inability to keep up with the class. Sandy seemed to blame herself, so her self esteem was threatened and she experienced anxiety. On the other hand, Randy and Rene, who were low in mathematics anxiety, seemed to blame the teacher. This finding seems to relate to attribution theory (see Marsh, Cairns, Relich, Barnes, & Debus, 1984; Weiner, 1980; Wolleat, Pedro, Fennema, & Becker, 1980). Perhaps high mathematics-anxious individuals attribute failure to ability or other internal causes, whereas low anxious ones attribute failure to external causes.

Mathematics-anxious individuals often perceive mathematics as rigid because of instruction which stresses computational rules without any explanation of why the rules work (Hilton, 1980; Kogelman & Warren, 1978). Widmer and Chavez (1982) found that less anxiety results when mathematics is taught for understanding than when computational rules are stressed. All of my interviewees had been taught mathematics rigidly. Sandy said one of the few positive experiences she had with mathematics was the few weeks she had in a prealgebra class. The teacher, "...made the class interesting. She opened up a lot of ideas, instead of just sticking you with the book, and brought out points of higher math." The rigidity would not lead to anxiety if the student is able to perform well, as Rene was, but would be threatening to self esteem when the student had difficulty meeting the rigid standards such as Linda, Sandy, and Dan.

The Nature of Mathematics

Although mathematics-anxious individuals' perception of mathematics as rigid is a misunderstanding, there are characteristics of the subject which seem to contribute to mathematics anxiety. One such aspect involves its cumulative nature; many mathematics skills and concepts are built on prerequisites. Smith (1979), in reporting generalizations

based on interviews with participants in a mathematics anxiety clinic, stated, "Math...was seen as accumulative and sequential; one bad year could ruin the rest" (p. 9). Descriptions of mathematics anxiety based on anecdotal reports often relate experiences of feeling lost after missing a mathematics topic (e.g. Gough, 1954; Mook & Legg, 1980). According to Lazurus (1974), part of the problem is that schools do not give children a second chance to make up missed work. As described previously, Sandy and Linda perceived this as part of their problem with mathematics. The review of topics in subsequent years was perceived as occurring on a more difficult level.

The abstract nature of mathematics also may contribute to mathematics anxiety. When asked why mathematics gave her particular difficulty, Sandy said one reason was because "Math even now doesn't seem tangible,. It seems out there, some other layer." Dan said in mathematics you are dealing with "Abstractions in terms of the ideal." Because of this abstract ideal, "there exists a process of exactitude which other sciences and arts don't require." The perfection he perceived as possible because of the abstractness of mathematics lead to anxiety when he was not perfect.

Situational Antecedents of Test Anxiety

Since a large portion of mathematics anxiety involves anxiety over mathematics tests (Dew, Galassi & Galassi, 1983; Rounds & Hendel, 1980), antecedents of test anxiety can also be considered antecedents of mathematics anxiety. Factors in the evaluative situation which have been associated with poor performance of high test-anxious individuals include the time interval between the administration of the threat and the actual occurance, task complexity, and achievement-oriented conditions (I. Sarason, 1972). Others include the personality of the examiner, the test-like character of the task (S. Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960), the importance of successful performance (Spielberger, 1978), and the stage the learning process is in; anxiety tends to debilitate early in learning and may facilitate later (Phillips, Martin, & Myers, 1972). All of the respondents in this study, except Denny, made statements indicating their level of preparation is a factor in how anxious they feel. Other factors mentioned include the level of understanding at the time of the test, the importance of the test, and having a time limit. It is easy to see how apprehension about being able to do well on a test could threaten self esteem and induce anxiety.

Environmental Antecedents

We can understand mathematics anxiety even better by adding a third type of antecedent: environmental. Like situational antecedents, they are factors from outside the individual. However, they have only an indirect role in anxiety-as-process, through their *past* effect on the personality of the individual. Environmental antecedents include parental encouragement, negative experiences with mathematics, and prior mathematics achievement.

Parental Encouragement

Encouragement involves active attempts to help as well as indications of belief in the abilities and worth of the individual. The two low mathematics-anxious interviewees seemed to receive a lot of encouragement from their parents to do well in school and in mathematics. The high mathematics-anxious ones, except Dan, either received little encouragement in all aspects of school, or a lot in other subjects, but little in mathematics. Dan said he was encouraged in mathematics and science, but he also felt pressured. He said, when he did not do well, his parents "were angry and hurt and they would start taking away privileges and would force me to spend more time...That's one of those things I blocked out, I just remember this real gray feeling."

Negative Experiences

Mathematics-anxious individuals often associate the beginning of their anxiety with negative experiences with mathematics (e.g. Gough, 1954; Kogelman & Warren, 1978). These experiences were threatening to self esteem and usually involved lack of success in the presence of a parent or teacher. Tobias (1978) stated, "Math anxious adults can recall with appalling accuracy the exact wording of a trick question or the day they had to stand at the blackboard alone, even if these events took place thirty years before" (p. 32).

Embarassment was mentioned several times in my interviews. Both Judy and Denny said their geometry teacher would yell at them; Judy's would say "You should know that" which made her feel like a "jerk" and Denny's would say, "Well, why can't you do this?" which made him feel "stupid". Judy remembered an incident in first or second grade when she misunderstood the directions and wrote down the next number of objects instead of the number of objects. Her parents and the teacher made "a big scene" over the F she got

on the paper. Sandy expressed the strongest feelings of embarassment, anxiety, and threat to self esteem when she said:

> When you are in school and you have got all those kids, to stand up in front of a blackboard and be called on...that just reinforced a lot of it because I would be so...petrified, 'cause I knew I didn't know it...And here is those fifty little faces looking at ya and you are standing there, looking at this blackboard thinking, "there is just no way I can do this".

Mathematics Achievement

Mathematics anxiety and achievement have a chicken-and-egg causality. Poor achievement in the past makes the present situation involving mathematics threatening to self esteem and, therefore anxiety inducing. That anxiety, in turn, can either facilitate or debilitate present achievement. Significant correlations have been found between various measures of achievement and the MARS (Clute, 1984; Hendel, 1977; Richardson & Suinn, 1972) or the MAS (Betz, 1978; Hackett, 1985; Kincaid, 1981), indicating high anxiety is related to low achievement but not the direction of causality. Each of the high mathematics-anxious individuals I interviewed stated or implied they had not achieved according to their expectations and this lack of achievement contributed to their anxiety. For example, Dan expected to be perfect in mathematics and so would experience anxiety if he received a "C" or even a "B" in the subject. Rene, who was low in mathematics anxiety, seemed to be successful in mathematics except during high school geometry. She experienced anxiety while taking this class, but not at other times.

In the other direction, all my interviewees, except Linda, perceived anxiety as debilitating. Four of the high mathematics-anxious interviewees recognized there is something similar to anxiety which can facilitate performance, but they labeled it tension, nervousness, or pressure, rather than anxiety. Munz and Smouse (1968) formulated an hypothesis, called the inverted-U, that there is a curvilinear relationship between test anxiety and achievement. According to this hypothesis, there is a degree of anxiety arousal which is optimal for performance and individuals with median levels of anxiety will perform better than those with either very high levels or very low levels of anxiety arousal. Towle and Merrill (1975) found evidence to support the inverted-U hypothesis for mathematics test performance.

Avoidance of Mathematics

The relationship between avoidance of mathematics and mathematics anxiety is as complex and interrelated as that between mathematics anxiety and achievement. There is some evidence anxiety was a factor in my high mathematics-anxious interviewees' avoidance of mathematics, indicating the latter is one method of coping with the former. For example, Denny stated, "Well, I had so many problems in math in general, I think it might have been, 'Do you really want to go through a whole year of this, all this anxiety again?'" Also, Sandy, when she returned to her seat after being embarassed at the chalkboard in first grade, said she felt, "Kinda relief it was all over...Just kinda retreated, you know, just kinda pretended like it didn't exist...I'd get way down in the seat and try to hide. Anything I could do to avoid the situation."

Not only is avoidance the prominent means of coping with mathematics anxiety, it also might be an antecedent as evidenced by the significant correlations between mathematics anxiety in college students and their high school mathematics preparation (Betz, 1978; Frary & Ling, 1983; Hackett, 1985; Hendel, 1977). Linda stated her anxiety was related to not taking more mathematics in high school "because I don't have that much confidence in it, 'cause I know the background isn't there."

Finally, the syndrome of mathematics anxiety and avoidance seemed to contribute to my interviewees' avoidance of jobs, mathematics courses, other courses, certain careers, balancing their checkbooks, and colleges requiring a lot of mathematics. Also, Dan did not complete his master's thesis in mass communications because of a required statistics course. Consistent with this finding, Widmer and Chavez (1982) found significantly more of the mathematics-anxious elementary teachers they studied showed evidence of having careers goals inhibited by mathematics than did their non-anxious counterparts. Also, Hackett (1985), in a path analysis, found evidence that mathematics anxiety directly and indirectly influences choice of a mathematics-related college major.

Discussion

This paper presents a model for understanding and studying mathematics anxiety based on the literature on anxiety, test anxiety, and mathematics anxiety, plus interview

data. This model is summarized in Figure 1, which is an expansion of anxiety-as-process.

Insert Figure 1 about here

Environmental antecedents occur in the past and have an indirect effect on the immediate anxiety reaction through dispositional antecedents. *Dispositional* antecedents determine whether or not the individual will perceive the stressor as threatening to self esteem. *Situational* antecedents surround the stressor and contribute to the perception of threat. It is an interaction of these antecedents which produces an anxiety reaction, with it's physiological manifestations. During cognitive reapraisal, decisions are made about dealing with the anxiety. Perhaps, if self esteem is basically strong and there is a certain level of task-related confidence, the individual can control the anxiety and channel it into the task. When this occurs, the anxiety might facilitates performance. However, if the individual is unable to control the anxiety, it can debilitate preformance. A feedback loop might occur in which anxiety is increased (Buxton, 1982). These are ways the individual copes (or does not cope) with the immediate anxiety situation. Coping for long-term might involve avoidance of mathematics and convincing oneself mathematics is not useful.

This expanded model is a rich source of hypotheses for research exploring the nature of mathematics anxiety. Letting A represent a specific antecedent, one hypothesis, in general form, might be:

> More high mathematics-anxious individuals report A than low mathematics-anxious individuals.

For example:

> More high mathematics-anxious individuals have felt something was wrong with them because they could not do mathematics than low mathematics-anxious individuals.

Or:

> More high mathematics-anxious individuals have had an extremely negative experience with mathematics than low mathematics-anxious individuals.

This general form can be expanded for exploring some of the more complex antecedents, such as sex role.

> More high mathematics-anxious females feel they were not encouraged in mathematics than low mathematics-anxious females (or than high mathematics-anxious males).

Also:

> More high mathematics-anxious males feel they were pressured to do well in mathematics than low mathematics-anxious males (or than high mathematics-anxious females).

In addition to generating individual hypotheses, the model as a whole could be validated using path analysis. Path analysis also could be used to test other possible antecedents and to untangle the causal order of (a) mathematics anxiety and avoidance, (b) mathematics anxiety and achievement, and (c) mathematics anxiety and perceived usefulness. Also, more research is needed on cognitive reappraisal. What cognitions are present in individuals who control their anxiety which are not present in individuals who do not? Is level of confidence a determining factor between the two? Are the belief systems discussed by Schoenfeld (1983) crucial in cognitive reappraisal and/or perception of threat? Does what the individual believes about self, about mathematics, and about self as a learner of mathematics play a crucial role in whether or not the individual will experience anxiety and how he or she will deal with it?

One recent trend in research on affective variables in mathematics education has been away from general scales measuring global attitudes to scales measuring more specific constructs, such as the Fennema and Sherman Mathematics Attitude Scales (1976). Research would benefit from even more such scales. Quotes from the interviews reported here could be used to develop at least two scales: (a) the perception of mathematics as rigid, and (b) avoidance of mathematics. Both scales would be useful in research on the interrelationships among various affective factors and their impact on learning mathematics. The former might be used in assessing programs or courses designed to counteract the percep-

tion of mathematics as rigid, especially for preservice and inservice elementary teachers. The latter might be useful in separating individuals who actively avoid mathematics from those who chose not to enroll for other reasons. Two different programs would be needed to encourage participation; an extensive one for the avoiders and a briefer, relatively economical one, for the other nonparticipants. An eighth grade version of the avoidance scale could be used to identify avoiders for treatment before they have a chance to take a minimal amount of mathematics in high school.

Finally, future research might explore the relationship of mathematics anxiety to other constructs such as attributions of success and failure. Do high mathematics-anxious individuals tend to attribute failure to internal causes and low mathematics-anxious individuals, to external ones?

In conclusion, this paper presents a model of a mathematics anxiety reaction which incorporates most of the major themes discussed in the mathematics anxiety literature. The model is built upon Spielberger's conceptualizations of anxiety as state, trait, and process. Since anxiety-as-process involves a temporal ordering of events in the anxiety situation, causality is implied and caution is necessary when arguing that certain correlates of mathematics anxiety are antecedents. However, if such caution is taken, the model can provide a valuable theoretical basis for future research on this complex phenomenon.

Table 1

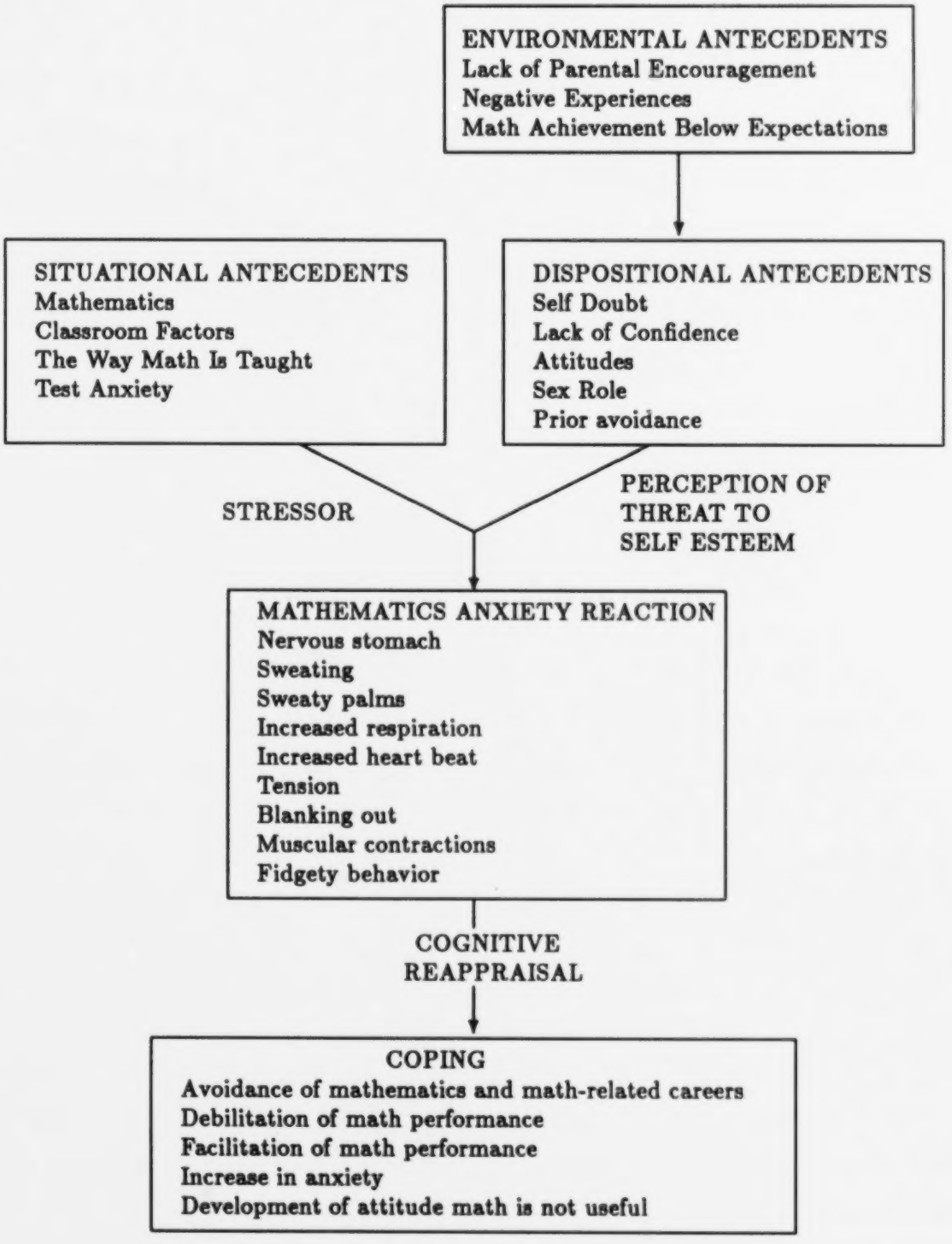
Respondents

Psuedonym	Subjective rating mathematics anxiety	Percentile[a] score on MARS[b]	Age	Sex	University status	Referred by
Sandy	high	Over 95th	29	female	Taking continuing education classes	Researcher
Judy	high	80th–95th	24	female	Junior, painting	Art Professor
Dan	high	80th–95th	34	male	Taking mathematics classes, had MA in Tibetian studies	Friend of researcher and math instructor
Denny	high	60th	19	male	Freshman	Instructor, introductory algebra
Linda	high, but lower than others	50th	19	female	Freshman	same as Denny
Rene	low	5th–20th	24	female	Sophomore, elementary education	Instructor, elementary math methods
Randy	low		20	male	same as Rene	same as Rene

[a] Based on norms provided by Richardson and Suinn (1972), freshman norms for Denny and Linda, undergraduate norms for others.

[b] Mathematics Anxiety Rating Scale

Figure 1
MODEL OF A MATHEMATICS ANXIETY REACTION



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